

TINTYAVA EXPLORATION AD

Report on hydrogeological conditions in the Rozino Deposit IP area

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1 Introduction

Tintyava Exploration AD is in the second two-year extension of the contract with the Ministry of Energy for prospecting and exploration in the Tintyava PLA in the Eastern Rhodopes. Having submitted the report on gold ore reserves to the Bulgarian Ministry of Energy for registration of a commercial discovery of the Rozino gold deposit, Tintyava Exploration AD started deposit development preparations. According to the Mineral Resources Act, commercial discovery certificates are issued following presentation of an enacted positive EIA statement. Currently, Tintyava Exploration AD has started the procedure referred to in Chapter 6 of the Environment Protection Act and has submitted an investment proposal for development of the Rozino Deposit in the Ivaylovgrad Municipality.

The Jess-E EOOD consulting company was hired to study the hydrogeological conditions in the Rozino Deposit Investment Proposal area with the idea that the study should be used by a team of experts assessing the environmental impacts of mine development and mining.

This report presents the results from the works to describe the hydrogeological conditions in the Rozino Deposit Investment Proposal area.

2 Location of the Rozino Deposit Investment Proposal Area

The investment proposal (IP) is situated in the Ivaylovgrad Municipality, Haskovo District (Figure 1).

The Rozino Deposit IP area is 304.5 ha in the lands of the Rozino and Gugutka villages (Figure 2) with 173.6 ha of that area being a buffer zone and 130.9 ha being allocated for mining facilities. Both villages are accessed by asphalt surfaced roads following which third-grade forest and unsurfaced roads are used to access the property. The villages have electricity. The main water artery in the region is the Byala Reka River.

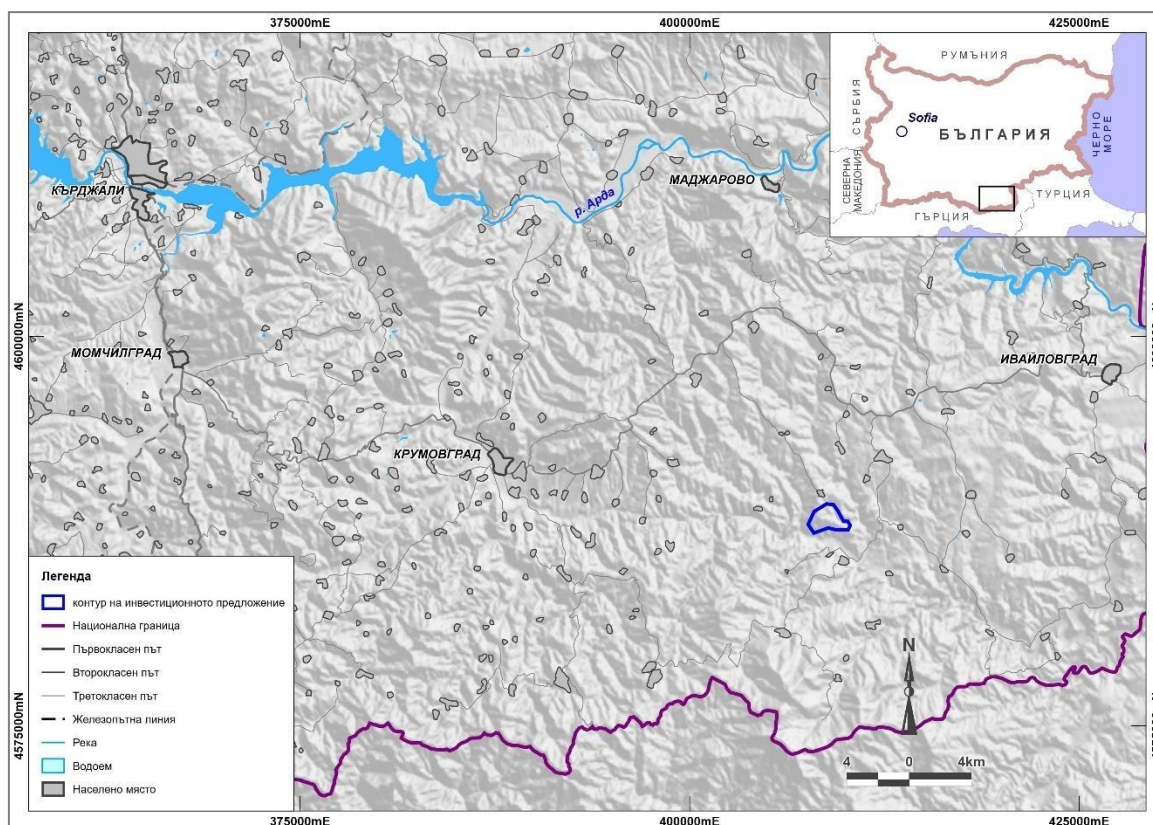


Figure 1. Location of the Rozino Deposit Investment Proposal Area.

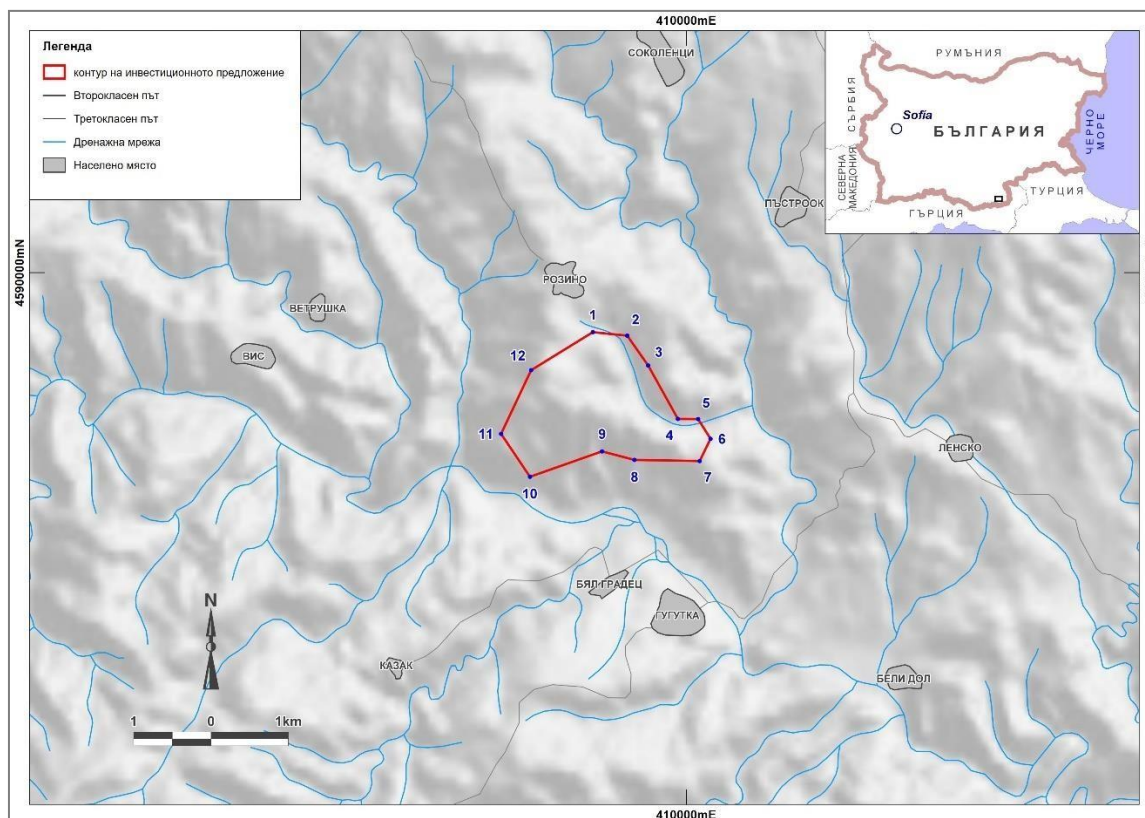
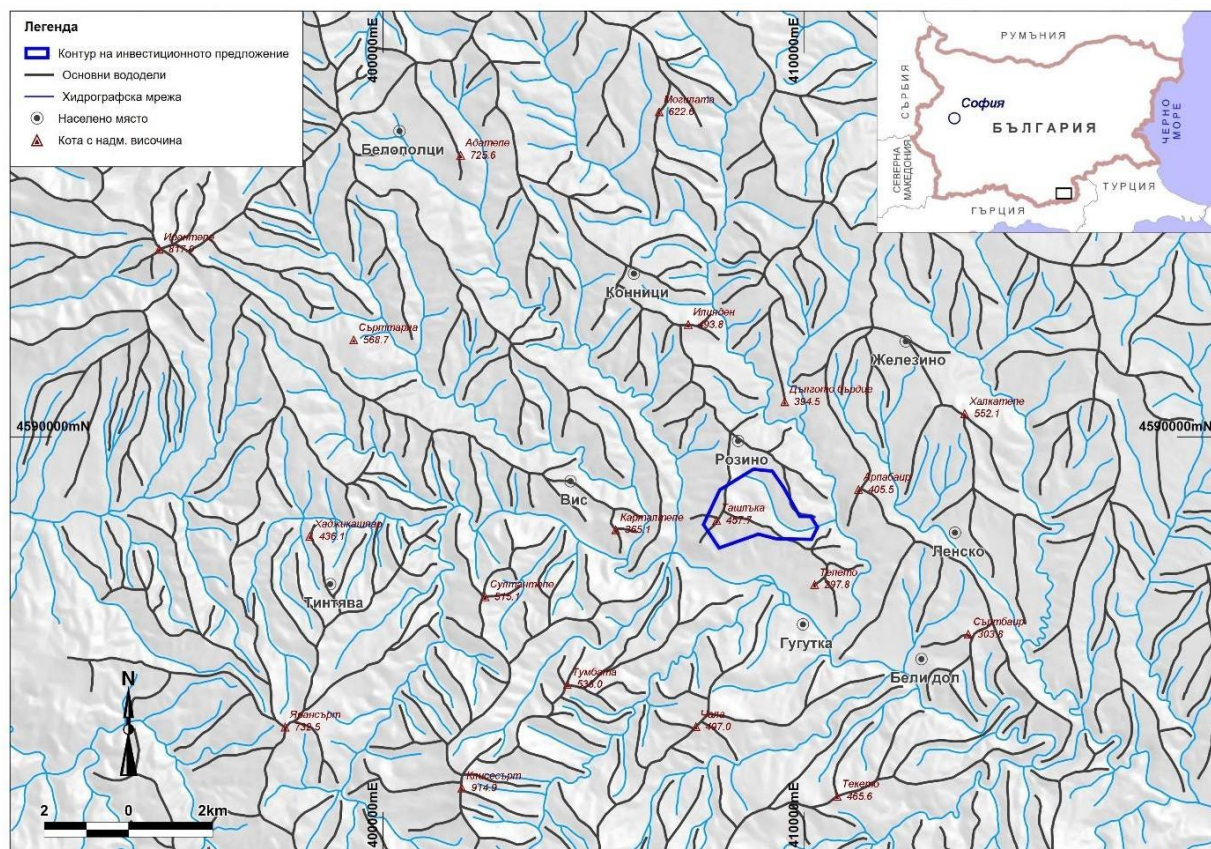


Figure 2. Outline of the Rozino Deposit IP and infrastructure in the region.

3 General physical and geographical information about the region

The topography in the area is low-mountainous and hilly, with level hills being prevalent. The elevation above sea level varies between 70 and 700 m., in the broader geographical perspective, averaging at 320 m. The heights in the IP area are also around this average. The highest point is the Tashlaka peak, with 457.7 m. (Figure 3). Its surrounds are dissected by the tributaries of the Byala Reka River whose floodplain elevation to the south (external to the IP) is 230 – 235 m.

Figure 3. Hydrographic network and main watershed areas in the studied region.



The studied area belongs to the Gyumyurdjin-Maglenishka geographic sub-area. Its proximity to the Aegean basin is a factor for the transitory-Mediterranean climate with the onset of transitory-continental climate to the north of the Biala Reka River. The average annual temperature is 12-13°C and the average in January is 1-2°C, while the July average is 23-24°C.

Winters are relatively mild, the coldest months being January and February. Snowfalls during this period vary between 30 and 50% of the precipitation total, and the snow cover does not last for more than 4-6 days. In spring the temperature begins to stay steadily above 5°C during the second half of March. Summers are sunny and warm, with the average monthly temperature of the hottest months (July and August) being 24°C and highs of 36-38°C are infrequent. Autumns are also warm, with an average temperature in October of 10.5°C. The temperature remains persistently lower than 5°C by late November.

The wind direction in the open spaces is mainly from the north and north-west, with a second maximum from south-southeast. Winds are affected by topography and frequently follow the valleys.

Annual cloud covers are the highest in winter (52-65%) and are lowest in summer (30-35%).

Relative humidity highs occur during the cold part of the year with similar values of around 80% during all months. In the summer, the relative humidity varies between 65% and 70% with a low in August.

The annual number of foggy days is well represented with a high in winter (3.3 - 3.5 days) and a low in July and August when frequently no fogs occur throughout the region or the number of days with fog is 0.1 to 0.3.

The annual average precipitation varies widely with a high in winter (November, December), when the monthly average is 95 to 135 mm/m². Precipitation in spring is marginally lower than in winter but accumulation of some winter precipitation in the form of snow cover and spring snow melt make for equal drainage conditions during these two seasons. Monthly precipitation lows of 45-55 mm/m² are observed in August or September.

The hydrological regime is determined mainly by the climate, the geological and geomorphological conditions and the topography, with the structure of the soil-plant structure of the watershed area coming second. The so-called Mediterranean flow distribution is typical of the area. A significant proportion of the flow occurs between November and March-April, with a pronounced early spring high caused by snow melt and rainfall. The flow module varies between 5 and 25 l/sec/m², given an average annual precipitation of 700 to 1,100 l/m².

4 State of research of the region

The geology of the Rozino Deposit area has been studied in detail in the past and, also, in the present times. Unfortunately, the state of research as regards the engineering and geological conditions and the hydrogeological conditions is extremely poor. Hydrogeological testing and project studies carried out in the past to provide water supply for the villages of Gugutka and Rozino have not been archived and are not available in the Water Supply and Sewage EOOD company of Haskovo.

In the past, the geological structure of the Rozino Deposit has been the subject of a 1:100,000 scale geological mapping, with a later mapping to a 1:25,000 scale, with 1:100,000 and 1:50,000 scale maps having been issued.

In 2001, the right for prospecting and exploration in the Rozino Deposit, overlapping with the current Tintyava PLA had been granted by the MOEW to Hereward Ventures Bulgaria AD (HVB) and, subsequently, transferred to Karakal Cambridge Bulgaria EAD (previously named Ivanhoe Hereward Bulgaria EAD). Data from these geological studies are presented in the respective 2004, 2006, 2008 and 2009 reports. (See Section 10, References.)

In the period 2017-2004, the right for prospecting and exploration had been transferred to Gorubso – Kurdzhali AD and, subsequently, in 2018, to Tintyava Exploration AD. Mainly exploration and evaluation was carried out during this period in the Rozino Deposit, with less prospecting in the remaining parts of the property. This has resulted in a preliminary economic assessment with estimates and registration of the reserves in the Rozino deposit. Also, work on pre-feasibility study was started, with monitoring to gather data for the EIA.

The hydrology and hydrogeology studies in the license area are also related to this period following 2017.

The hydrological evaluation of the flow of the Byala Reka River and of its tributary Arpa Dere River was made in 2019 when data about various typical-year flow-distribution parameters had been presented (V. Slavov, 2019).

Hydrogeological testing had been carried out in 2019 in exploratory wells and test pits around the design Rosino Deposit pit. Hydraulic tests and Lugeon tests had been carried out in those workings to determine the rock and soil seepage ratios in the studied area (Golder Associates, 2019).

Proektirane i Analizi EOOD carried out an initial study of the possibility to build a pumping station to provide the necessary water resources for the site. The main conclusion was that a fresh-water pumping station is a technically feasible solution for providing the necessary water quantities to the site while complying with the environmental requirements for a minimum water flow in the river bed (Proektirane i Analizi EOOD, 2020).

An initial hydrogeological study of alluvial deposits in the region had been carried out in two locations - one in a borehole in the flood plain materials of the Byala Reka River and one in the floodplain of the Arpa dere River (Jes E EOOD, 2020). This study showed better prospects for the alluvial sediments of the Byala Reka River.

Hydrogeological testing of groundwater in the Palaeogene sediments were carried out in three investigation boreholes in 2020 (Jes E EOOD, 2020). Their results show that the ground water cannot be considered a potential water-supply resource because of their low seepage ratio.

Pumping tests were carried out by abstraction of water in two pipe wells in the alluvial deposit of the Byala Reka River (Jes E EOOD, 2021).

In 2020, GCS reviewed the water resource evaluations for the Rozino Deposit Project (GCS, 2020). Their report reviews the available hydrology and hydrogeology data, and the possible scenarios water-resource management scenarios for the mining project.

5 The Geological Setting

The Rozino Deposit is located in the Eastern Rhodope fall east of the Belorechki cupola. It has formed in a Palaeogene graben, typical of the Eastern Rhodopes, and filled mainly by terigenous coarse clastic sediment and by volcanogenic sediments. Hydrothermal activity was caused during the late Oligocene from hypoabyssal intrusives of medium acidity that has formed epithermal gold mineralisation.

Figure 4 below presents a geology map of the region. Several highly metamorphous complexes, mesozoic (?) schists and aplitic granites, which are superimposed between one another, are delineated in the Palaeogene basin. The following basement sequences are described as a result of the exploration - top rock of migmatite, serpentinite, amphibolitic complex and marbles, and bottom rock of gneiss and granites.

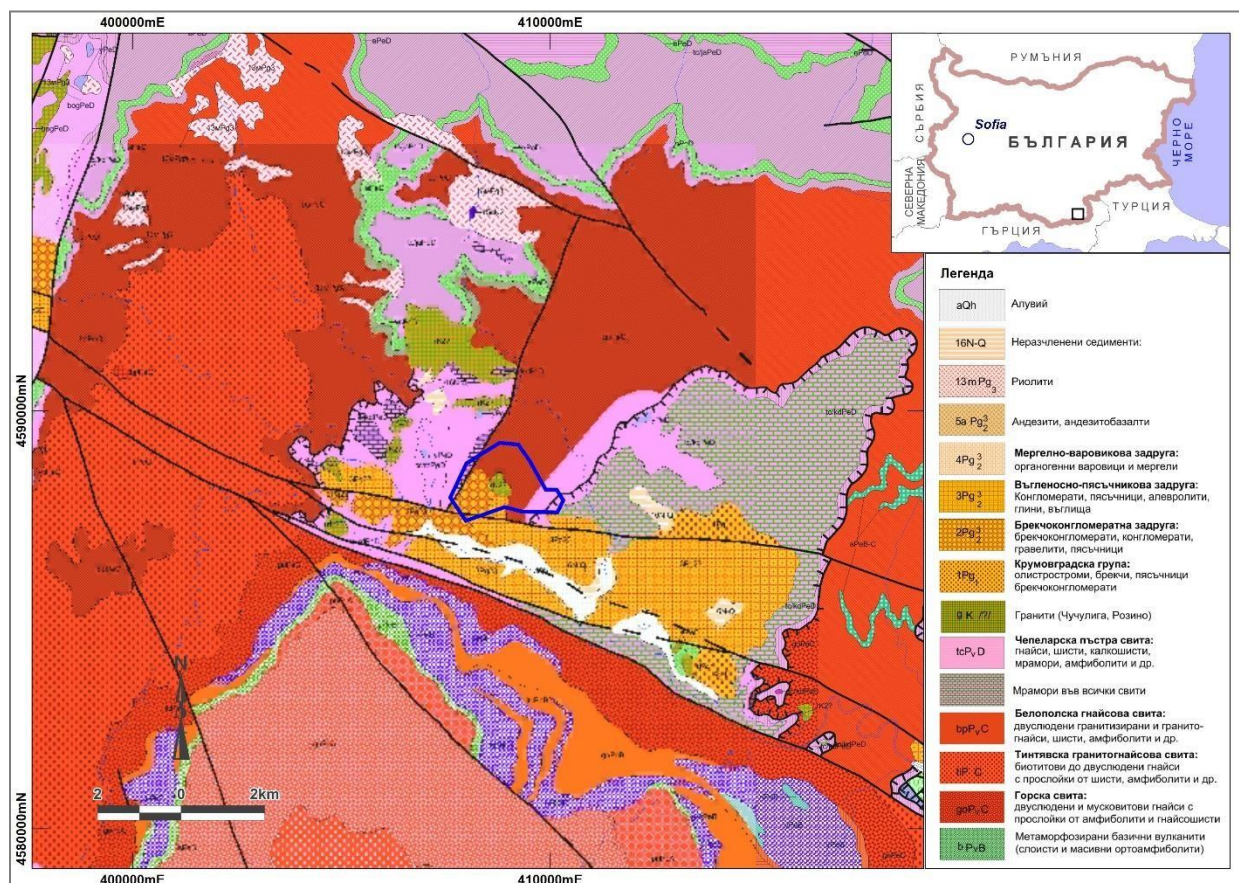


Figure 4. Geology map of mapped area, scale = M 1:100,000.

Two suites are represented in the Palaeogene sediment area - a breccia-conglomerate and a coal-bearing sandy suite of Preabonian age. These suites are 800 - 1,000 m. deep and, respectively, 100 to 800 m. deep.

The breccia conglomerate suite comprises pieces of the metamorphous foundation, granite blocks, ultrabazites, and diaphorites with sandy and coal-sandy bindings.

The coal-sandy suite comprises polymictic sandstones with limestone-clayey binding, gravel conglomerates, aleurolitic sandstones, marls, coal schists and coal.

Drift, eluvial and alluvial clays, sands and gravel represent the Quaternary deposits. The drift sediments and the collovium comprise mainly siltstone and sand-gravel clays, forming an almost uninterrupted surface of insubstantial thickness. The alluvial sediments comprise gravel and sand in varying ratios, rarely cut by clay-siltstone intercalations and are the material forming the valley beds and floodplains of the Byala Reka River and of its tributaries.

As is mentioned above, hydrothermal activity is the cause of deposition of precious metals and polymetal mineralization in the region. Gold concentration in the deposit has been concurrent with the formation of the

quartz-adularia metasomatites, and that lead, zinc and copper have formed jointly with the argilization and with the formation of argilisite type of metasomatic replacements. The favourable environment for deposition of ore mineralizations is provided by the breccia conglomerates, in the case of gold, and by the metamorphites, in the case of lead and zinc mineralizations. The geological scheme of the deposit is presented on Figure 5 below.

The ore bodies in the deposit have a complex morphology, steeply dipping and almost horizontal. The main ore body belongs to a geochemical anomaly along a secondary geochemical halo.

The ore mineralization is scarce. Minerals such as pyrite, marcasite, chalcopyrite, sphalerite, galena, magnetite and secondary copper minerals are established. The metallic minerals are finely injected or form fine veinlets. No visible gold has been observed. The native gold contains irregular and oval inclusions in pyrite, 0.01 to 0.1 mm in size.

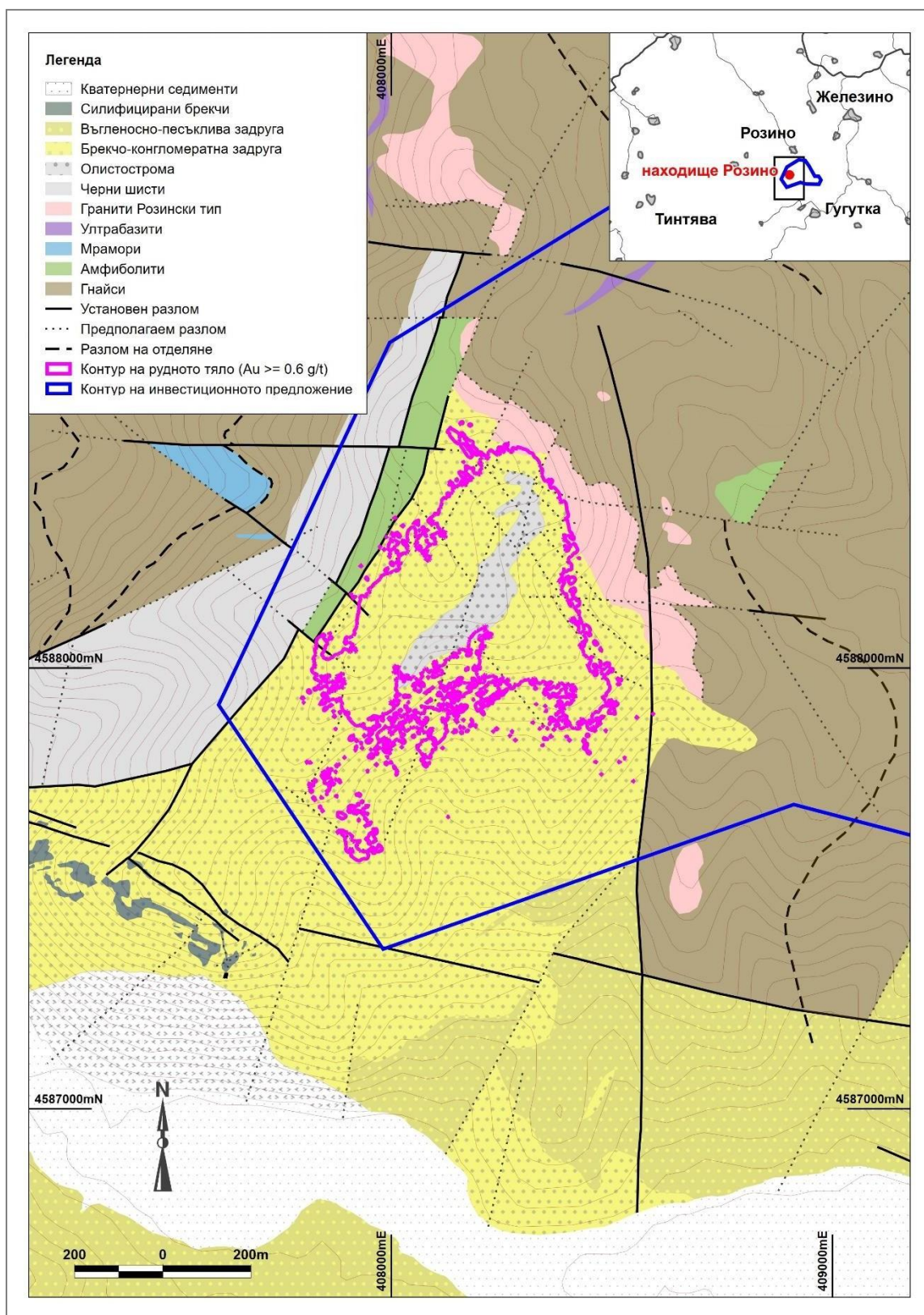


Figure 5. Geological scheme of the Rozino Deposit
(using data from the mapping by Tintyava Exploration AD)

6 Regional hydrogeological conditions

According to Bulgaria's adopted nomination, the groundwater bodies in the studied area around the Rozino Deposit are attached to a ground water body (GBW) with code BG3G000PtPg049 - Fissure Water – the Eastern Rhodopean Complex.

Alluvial deposits comprising boulders, inequigranular rubble and sand in varying ratios have formed along the Byala reka river in the studied region and include sandy-clayey lenses and intercalations. They are more than 5 - 6 m. deep in some parts. These deposits are external to the BG3G000000Q010 - Pore Water in Quaternary - Arda River groundwater body. Having unsustained areas, these bodies are not of economic interest and are not nominated as a delineated groundwater body and are not included in the List of Groundwater Bodies in the East Aegean Region:

Ground water body BG3G000PtPg049 - Fissure – Eastern Rhodopes Complex.

The following bodies have been nominated during the initial delineation of groundwater body aquifers in the area under consideration, as indicated under item 2 of Attachment II of the Water Framework Directive 2000/60/EC: GBW-BG3G00000Pt046 - Fissure water in Proterozoan Gneiss, Gneiss-Schists, Migmatites, and GBW-BG3G00000Pg028 - Fissure water in Paleogenic Sediments and Volcanoes. (East Aegean Basin Directorate, River Basin Management Plan 2010-2015, Section 1, Attachments 1-6 and 1.7). Upon completion of the 'Study of transboundary groundwater bodies between Bulgaria and Greece BG-GRGBW' project, 8 of the initially defined GBWs, including GBW-BG3G00000Pt046 and GBW-BG3G00000Pg028, were united and nominated as GBW BG3G000PtPg049 (East Aegean Basin Directorate - River Basin Management Plan 2016-2021, Section 1, Attachments . 23 and 24).

Furthermore, lithology types of a rather diverse type and age are included in this generalized geological and lithological section of GBW BG3G000PtPg049. The geological formations in the studied region are represented by a metamorphous base (migmatites, serpentinites, amphibolites, marbles, gneiss and granite) and by a Palaeogene sediment complex (breccias and conglomerates, polymictic coarse-grained to aleuritic sandstones, marls and coal schists).

The ground water circulates exclusively along mechanical disturbances such as fissures and tectonic discontinuities in those virtually water-tight lithological types. The non-uniform water-bearing capacity of these rock formations is determined by rock geology and lithology and, most of all, by irregular jointing and faulting.

Depending on the depth of flow and accumulation, fissure water can be divided conditionally into water within the active water exchange above the local erosion base level and water circulating deeply below the erosion base level.

The water in the active water-exchange area are cold, with temperatures of up to 15-17°C. The main source of groundwater in this GBW is seepage related to precipitation. Recharging of the water is directly dependent on the precipitation regime. In this transitional-Mediterranean climate, the ground water in the area is recharged mainly through direct seepage during the winter, longer precipitation and snow melt. Precipitation of short duration and significant transpiration and evapotranspiration in the summer mean that the groundwater is poorly recharged during this period.

Most often, the fissure water in the active water-exchange area is uncontained. It drains over the erosion base level and feeds small springs with flow rates of up to 0,050-0,200 l/s. Most of the springs dry up during the period of draught and their flow rates increase during the rainy period.

Deeply circulating fissure water in the gneiss and in the Palaeogene sediments accumulate below the erosion base level, in the zone of tectonic jointing. The deeply circulating fissure water is recharged also through seepage of precipitation and surface flowing water. The temperature of this water goes as high as 20°C. This water creates an aquifer classified as fissure and not of poor availability.

The lithological types comprising GBW BG3G000PtPg049 are, from the hydrogeological perspective, highly water tight and explain the low abundance of water in this GBW. Therefore, this water body is of no interest as a

water supply source and has not been the subject of targeted prospecting and evaluation hydrogeological studies for fresh water. It is, thus, one of Bulgaria's less well studied GWBs, as can be seen also from Attachments 23 and 24 to Section 1 of the 2016 - 2021 River Basin Management Plan of the Eastern Aegean Basin Directorate in Plovdiv. The averaged values of certain lithology types in GWB BG3G000PtPg049, determined mainly during exploration for ores and minerals, hydrotechnical construction etc., are as follows - porosity 1-2%, coefficient of filtration 0.0001-1 m/day, percentage of filtration <8 %, GWB depth from several meters to scores of meters.

7 Hydrogeological conditions in the Rozino Deposit IP area

This section presents the results from the hydrogeological studies in the Rozino deposit IP area. Similar studies were conducted by Golder Associates LTD and by Jes E EOOD between 2019 and 2021.

The results of the filtration tests to determine the filtration parameters of the lithology types (alluvial deposits of the Byala Reka River, delluvial and colluvial soils covering the rock bed, Palaeogene sediments such as limestones, sandstones and conglomerates, and Pre-Cambrian metamorphics) are presented and are the basis on which the filtration parameters of the lithology types established in the Rozino Deposit IP area are indicated.

Water samples have been taken during the studies in order to determine the chemical composition of groundwater flowing through GWB BG3G000PtPg049 and through the alluvial deposits in the Rozino target.

7.1 Permeability of lithology types

7.1.1 Quaternary lithology types

7.1.1.1 *Alluvial deposits*

In 2019 and in 2021 Jess E EOOD conducted a hydrogeological study of ground water in the alluvial sediments in the floodplains of the Byala Reka River and the Arpa dere River in and around the Rozino deposit area. Two boreholes were drilled and set up as piezometers (HPR 01 and HPR 02) and two pipe wells (AW 001 and AW 003) were used to test and determine the filtration parameters of the alluvial deposits. Inequigranular sands abundant in gravel and rare thin clayey-sandy lens comprise the floodplains. The alluvium in the studied areas is 6.0 – 7.0 m. deep around the Byala Reka River and 4.0 - 5.0 m. deep in the section near Arpa dere. The results of these tests are presented in Table 1 below.

Table 1.

Mine working No.	Tested interval from ... to...	Test conducted	Static water level	Seepage ratio
-	m	-	m	m/s
HPR 01	0.7 – 6.1	Abstractions	0.7	2.8×10^{-4}
		Recovery		2.6×10^{-4}
HPR 02	1.84 – 4.36	Abstractions	1.84	1.5×10^{-4}
		Recovery		1.6×10^{-4}
AW 001	1.15 – 3.8	Abstractions	1.15	3.8×10^{-4}
		Recovery		3.8×10^{-4}
AW 003	0.58 – 3.40	Abstractions	0.58	5.8×10^{-4}
		Recovery		4.8×10^{-4}

The transmissivity ratio 'a' of alluvial deposits of the Byala Reka River is $2.63 \times 10^3 \text{ m}^2/\text{day}$ and is $2,36 \times 10^3 \text{ m}^2/\text{day}$ in the alluvial deposits of the Arpa dere River.

Other boreholes were drilled into the alluvial sediments in 2021 and set up as groundwater level monitoring piezometers. Their results are presented in Section 7.2, while the chemical composition data are presented in Section 7.3 hereof.

7.1.1.2 *District colluvial soils*

In 2019, Golder Associates Ltd conducted hydrogeological studies of the delluvial and colluvial soils covering the Palaeogene sediments and the Pre-Cambrian metamorphous rocks forming the earth foundation of the Rozino Deposit. Six drillholes dedicated to the hydrogeological study were used for the filtration tests.

The delluvial and colluvial soils comprise sandy clays with inclusions of angular rock pieces of varying sizes and change over to clayey sands in some places. The Quaternary cover is ubiquitous, having been denuded in some smaller and steeper sections where basement rocks outcrop to the surface. The district colluvial soils and the colluvium vary in widely in depth, having been measured at up to 6 - 7 m. in some places.

The results of these filtration tests are presented in Table 2 below.

Table 2.

Mine working No.	Tested interval from ... to...	Test conducted	Water level	Seepage ratio
-	m	-	m	m/s
PP_BH 01	0 - 1.6	FHT	Dry	1.38×10^{-7}
PP_BH 02	0 - 1.6	FHT	Dry	1.06×10^{-6}
RWD_BH 03	0 - 5.3	FHT	Dry	3.4×10^{-7}
TSF_BH 03	0.6 – 1.4	FHT	Dry	1.52×10^{-6}
WRD_BH 01	0 – 1.75	FHT	Dry	4.25×10^{-7}
WRD_BH 02	0 -1.0	FHT	Dry	8.24×10^{-7}

*FHT – Falling head test.

All tests in the Quaternary delluvial and colluvial soils have been carried out in dry intercepts, i.e. no where no ground water was found there.

7.2 Palaeogene sediment rocks and Proterozoan metamorphous rocks

In 2019 both Golder Associates Ltd and Jes E EOOD conducted hydrogeological studies of the rocks comprising the ground bed of the studied region. The groundwater in those rocks were designated as GWB BG3G000PtPg049 in accordance with the List of Groundwater Bodies in the East Aegean Region.

Tests to clarify the filtration parameters of the lithology varieties - Palaeogene sediments and metamorphous rocks - comprising the studied region were conducted. Prospecting and exploration boreholes and, also, dedicated hydrogeological study boreholes, were used for the filtration tests.

The groundwater body level results from the 2020 - 2022 studies are presented in Section 7.2, while the chemical composition data are presented in Section 7.3 hereof.

Table 2.

Mine working No.	Test No.	Lithological type	Test conducted	Permeability coefficient m/sec
RDD-148	1	Olistostrome	packer	2.13×10^{-9}
	2	Gneiss	FHT	1.02×10^{-8}
RDD-164	1	Sediments	packer	5.64×10^{-8}
	2	Gneiss	FHT	1.11×10^{-8}
RDD-153	1	Sediments	FHT	4.29×10^{-7}
RDD-160	1	Gneiss	FHT	2.32×10^{-7}
RDD-162	1	Sediments	FHT	1.45×10^{-7}
	2	Sediments	packer	1.27×10^{-8}
	3	Olistostrome	FHT	9.67×10^{-10}
RDD-151	2	Gneiss	packer	3.54×10^{-8}
RDD-156	2	Gneiss	FHT	3.09×10^{-8}
PP-BH-01	2	Gneiss	FHT	1.0×10^{-8}
PP-BH-02	2	Gneiss	FHT	2.94×10^{-8}
RWD-BH-01	1	Gneiss	FHT	7.15×10^{-9}
TSF-BH-01	1	Gneiss	FHT	5.35×10^{-7}
	2	Gneiss	FHT	1.28×10^{-6}
TSF-BH-03	2	Gneiss	FHT	4.42×10^{-7}
WRD-BH-01	2	Gneiss	FHT	4.75×10^{-8}
WRD-BH-02	2	Gneiss	FHT	4.42×10^{-8}
RDD 172	1	Sediments	Abstraction	2.66×10^{-9}
RDD 173	1	Sediments	Abstraction	7.71×10^{-10}

*FHT – Falling head test

Some tests showed integral transmissivity of the lithology types comprising GWB BG3G000PtPg049 of 0.02 to 0.069 m²/day.

8 Groundwater Levels

8.1 Quaternary deposits

Nine monitoring points were used to measure the levels of groundwater flowing through the alluvial materials comprising the floodplains of the Byala Reka River and of the Arpa dere River. Two of those piezometers were built in 2019 and the remaining ones were built in 2021. Their locations in the alluvial sediment is shown on Figure 6 below.

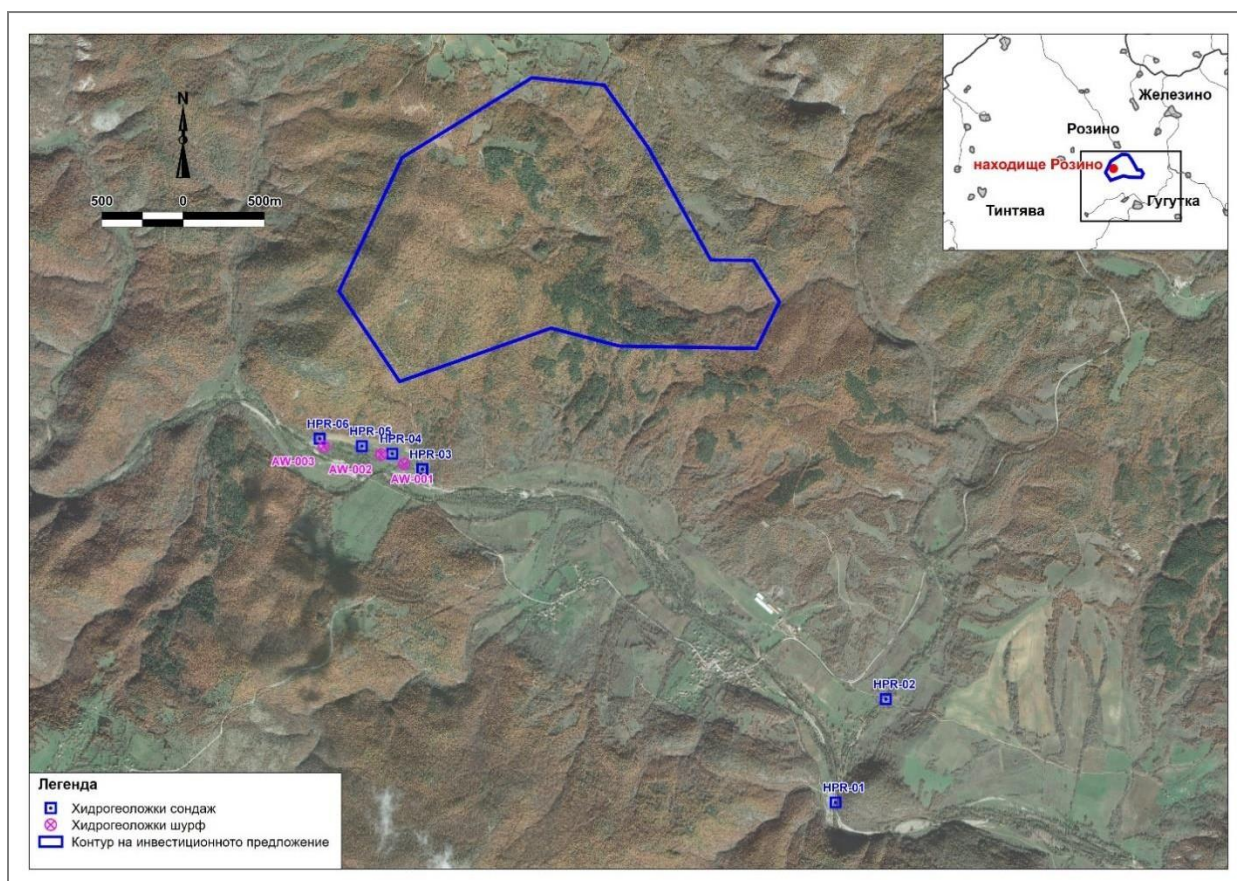


Figure 6. Location of groundwater monitoring points in the alluvial deposits of the Byala Reka River.

The monitoring point measurement results are presented in Table 3 below.

Table 3.

Mine working No.	Terrain level, m	Lowest water level from the surface m	Highest water level from the surface m	Average for the period m
HPR-01	221.26	0.90	0.04	0.58
HPR-02	220.54	2.18	0.90	1.39
HPR-03	231.90	3.40	0.86	1.56
HPR-04	233.14	3.48	0.97	1.75
HPR-05	233.93	3.70	0.84	1.62
HPR-06	235.81	4.15	1.23	2.16
AW-001	233.53	3.27	0.85	1.59
AW-002	234.05	2.91	0.44	1.18
AW-003	236.96	4.24	1.65	2.47

Water levels of 0.04 to 4.24 m. from the surface were measured in the monitored boreholes and are directly dependent on water levels in the Byala Reka River and in the Arpa dere River.

It was established during the hydrogeological studies in the delluvial and colluvial soils of the Quaternary cover of the Rozino section that no ground water flowed though those boreholes.

8.2 Palaeogene sediment rocks and Proterozoan metamorphous rocks in GWB BG3G000PtPg049

In the period between 2019 and 2023, Tintyava Exploration AD carried out periodic measurements of ground water bodies in 12 of the exploration boreholes.

The profile established in these boreholes is represented completely by the Palaeogene sediments and metamorphous rocks comprising GWB BG3G000PtPg049. Four of the boreholes were compromised during that period and measurements continued in the remaining 8 holes.

Their locations are shown on Figure 7 below and the measurement results are shown in Table 4.

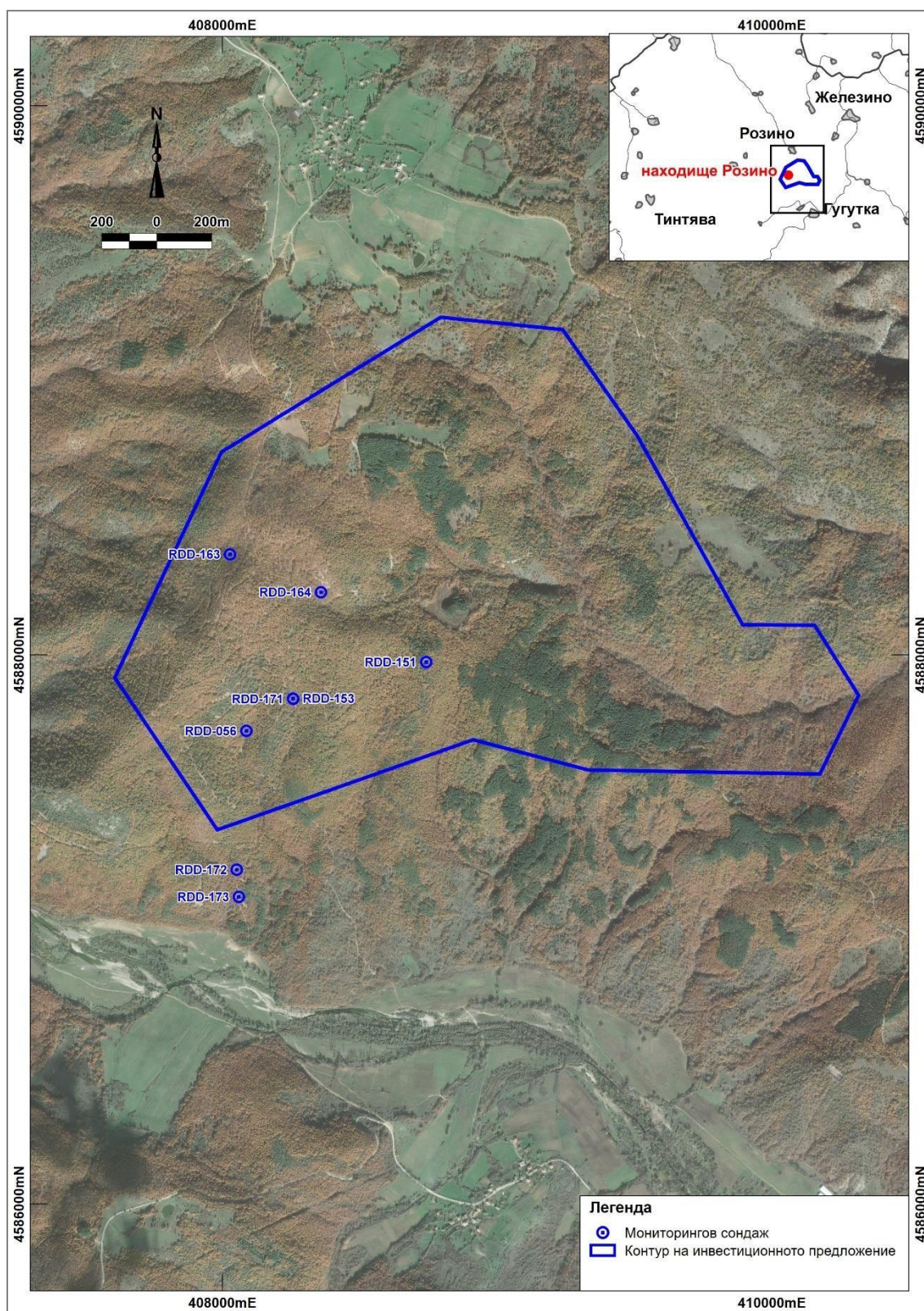


Figure 7. Location of the monitoring points in GWB BG3G000PtPg049.

Table 4.

Hole ID	Terrain level, m	Lowest water level from the surface, m	Highest water level from the surface, m	Average for the period m
RDD-056	368.75	free-flowing		
RDD-151	416.19	31.33	29.25	29.94
RDD-153	413.07	14.31	7.19	9.88
RDD-163	477.55	14.43	10.52	9.83
RDD-164	457.98	17.40	9.83	15.99
RDD-171	413.25	20.25	4.82	6.67
RDD-172	295.72	11.66	6.67	10.19
RDD-173	270.66	11.39	5.57	7.70

Water levels between 4.82 and 31.33 m. below the surface were registered in the monitored boreholes, with the averages in this period being 6.67 to 29.94 m. The water levels vary between 259.27 and 467.03 m. Borehole RDD-056 is an exception - the ground water there drain freely at elevation 368.75 m.

9 Chemical composition of the ground water

9.1 Alluvial sediments

Two samples taken from boreholes HPR 03 and HPR 06 were used to determine the chemical composition of ground water flowing thorough the alluvial sediments of the Byala Reka River.

The chemical test results are presented in Table 5 below.

Table 5.

Parameter	Units	Standard as per Regulation 1	Borehole HPR 03	Borehole HPR 06
pH	pH units	≥ 6.5 and ≤ 9.5	7.11 ± 0.11	7.28 ± 0.11
Electrical conductivity	$\mu\text{S/cm}$	2000	357 ± 11	267 ± 8
Total hardness	mgEqv/l	12	3.03 ± 0.15	2.37 ± 0.24
Permanganate oxidisable	mgO_2/l	5	0.88 ± 0.09	1.9 ± 0.2
Sodium	mg/l	200	15.2 ± 1.8	10.9 ± 1.5
Calcium	mg/l	150	40.2 ± 2.0	28.2 ± 2.8
Magnesium	mg/l	80	12.4 ± 1.2	11.7 ± 1.2
Aluminium	$\mu\text{g/l}$	200	174 ± 17	336 ± 34
Antimony	$\mu\text{g/l}$	5.0	<1.0	<1.0
Arsenic	$\mu\text{g/l}$	10	<3.0	<3.0
Boron	mg/l	1.0	0.008 ± 0.001	0.004 ± 0.001
Iron	$\mu\text{g/l}$	200	163 ± 16	357 ± 36
Mercury	$\mu\text{g/l}$	1.0	<0.05	<0.05
Cadmium	$\mu\text{g/l}$	5.0	0.32 ± 0.06	0.40 ± 0.08
Manganese	$\mu\text{g/l}$	50	8.4 ± 0.8	26 ± 3
Copper	mg/l	0.2	0.004 ± 0.001	0.009 ± 0.001
Nickel	$\mu\text{g/l}$	20	<2.0	<2.0
Lead	$\mu\text{g/l}$	10	<2.0	<2.0
Selenium	$\mu\text{g/l}$	10	<3.0	<3.0
Chromium	$\mu\text{g/l}$	50	<1.0	<1.0
Zinc	mg/l	1.0	0.004 ± 0.001	0.004 ± 0.001
Nitrates	mg/l	50	15.4 ± 0.6	0.93 ± 0.14
Nitrites	mg/l	0.5	<0.05	<0.05
Sulphates	mg/l	250	23.4 ± 1.0	20.2 ± 0.9
Fluorides	mg/l	1.5	<0.10	<0.10
Phosphates	mg/l	0.5	<0.10	<0.10
Chlorides	mg/l	250	11.1 ± 0.4	7.6 ± 0.4
Cyanides	$\mu\text{g/l}$	50	<5	<5
Natural uranium	mg/l	0.06	<0.020	<0.020

The comparison of studied parameter concentrations to the regulated values in the quality standard under Regulation 1 of October 10, 2007 on Exploration, Use and Protection of Groundwater showed a good chemical composition of the ground water in the alluvial sediments. The results are consistent with low content of the studied parameters as compared to the quality standard of Regulation 1.

Volatile organic compounds (VOC), organochloric pesticides, organophosphorous and organonitric pesticides, general pesticides, benzapirenes, and polycyclic aromatic hydrocarbons (PAH) are present in quantities below $0.010 \mu\text{g/l}$, and being less than 20 mg/l , which is lower than the values in the standard, oil products are not shown in the table. Together with low oil product, heavy metal and nutrient (ammonia, nitrates, nitrides, phosphates), these concentrations show that no human activity impacts the ground water in the studied area. Two parameters (aluminium and iron) measured in the sample taken from HPR 06 were slightly above than those in HPR 03 and the quality standard, most likely because of natural variations (these materials being the basic rock-forming materials).

Being very similar, the groundwater parameters that were studied in the sampled alluvial sediment areas are indicative of a comparatively steady chemical composition. According to the data, the condition of this ground water is good, and its quality is not affected by human activity (whether farming or exploration). It should be noted, therefore, that as it is noted above, these results can serve as a background characterization of the chemical composition of alluvial ground water in the region.

9.2 Groundwater in the Palaeogene sediments and in the Metamorphous basement

The chemical composition of the ground water flowing through the Palaeogene sediments and through the metamorphous basement is presented by the results of eight samples studied in 2019 and one sample studied in 2022. The data are presented in Table 6.

Table 6.

Parameter	Units	Standard as per Regulation 1	RDD 005	RDD 011	RDD 016	RDD 021	RDD 027
pH	pH units	≥ 6.5 and ≤ 9.5	7.25	7.09	6.99	6.96	7.27
Electrical conductivity	$\mu\text{S}/\text{cm}$	2000	474	894	611	504	615
Total hardness	mgeqv/l	12	5.36	9.33	7.48	5.31	7.18
Permanganate oxidisable	mgO_2/l	5	3.6	4.7	5.3	0.7	2.7
Sodium	mg/l	200	10.8	42.1	7.5	19.9	14.4
Calcium	mg/l	150	92	147	125	82	104
Magnesium	mg/l	80	9.3	23.9	14.9	14.8	23.8
Aluminium	$\mu\text{g}/\text{l}$	200	<8.0	<8.0	<8.0	25	<8.0
Antimony	$\mu\text{g}/\text{l}$	5.0	<2.0	<2.0	<2.0	<2.0	<2.0
Arsenic	$\mu\text{g}/\text{l}$	10	<5.0	<5.0	<5.0	34	<5.0
Boron	mg/l	1.0	0.011	0.013	0.011	0.0094	0.0095
Iron	$\mu\text{g}/\text{l}$	200	14	5.0	5.1	6.3	14
Mercury	$\mu\text{g}/\text{l}$	1.0	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	$\mu\text{g}/\text{l}$	5.0	<1.0	<1.0	<1.0	<1.0	<1.0
Manganese	$\mu\text{g}/\text{l}$	50	1200	2600	70	300	1200
Copper	mg/l	0.2	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Nickel	$\mu\text{g}/\text{l}$	20	26	15	2.5	11	4.8
Lead	$\mu\text{g}/\text{l}$	10	<2.0	<2.0	<2.0	<2.0	<2.0
Selenium	$\mu\text{g}/\text{l}$	10	<5.0	<5.0	<5.0	<5.0	<5.0
Chromium	$\mu\text{g}/\text{l}$	50	<1.0	<1.0	2.2	<1.0	<1.0
Zinc	mg/l	1.0	0.21	0.88	0.73	0.44	0.72
Nitrates	mg/l	50	<0.50	2.2	2.2	<0.50	1.9
Nitrites	mg/l	0.5	<0.05	<0.05	<0.05	<0.05	<0.05
Sulphates	mg/l	250	10.1	50.0	20.7	13.3	10.2
Fluorides	mg/l	1.5	<0.10	0.13	0.13	0.11	0.14
Phosphates	mg/l	0.5	<0.10	<0.10	<0.10	<0.10	<0.10
Chlorides	mg/l	250	5.5	40.8	112	13.5	11.7
Cyanides	$\mu\text{g}/\text{l}$	50	<5	<5	<5	<5	<5
Natural uranium	mg/l	0.06	<0.020	<0.020	<0.020	<0.020	<0.020

Table 6 – contd.

Parameter	Units	Standard as per Regulation 1	RDD 035	RDD 049	RDD 056	RDD 202
pH	pH units	≥ 6.5 and ≤ 9.5	7.02	7.02	7.63	7.04
Electrical conductivity	$\mu\text{S}/\text{cm}$	2000	534	410	658	640
Total hardness	mgeqv/l	12	6.21	4.57	7.02	5.69
Permanganate oxidisable	mgO_2/l	5	<0.50	4.7	<0.50	1.8
Sodium	mg/l	200	12.2	10.4	18.8	10.7
Calcium	mg/l	150	80.4	64	96	75
Magnesium	mg/l	80	26.8	16.7	27.1	23.4
Aluminium	$\mu\text{g}/\text{l}$	200	<8.0	62	<8.0	61
Antimony	$\mu\text{g}/\text{l}$	5.0	<2.0	<2.0	<2.0	<1.0
Arsenic	$\mu\text{g}/\text{l}$	10	<5.0	6.4	7.6	8.4
Boron	mg/l	1.0	0.013	0.022	0.0072	<0.003
Iron	$\mu\text{g}/\text{l}$	200	34	48	5.0	1410
Mercury	$\mu\text{g}/\text{l}$	1.0	<0.05	<0.05	<0.05	<0.05
Cadmium	$\mu\text{g}/\text{l}$	5.0	<1.0	<1.0	<1.0	0.34
Manganese	$\mu\text{g}/\text{l}$	50	600	670	9.6	152
Copper	mg/l	0.2	<0.0030	<0.0030	<0.0030	0.0006
Nickel	$\mu\text{g}/\text{l}$	20	13	26	<2.0	<2.0
Lead	$\mu\text{g}/\text{l}$	10	<2.0	<2.0	<2.0	<2.0
Selenium	$\mu\text{g}/\text{l}$	10	<5.0	<5.0	<5.0	<3.0
Chromium	$\mu\text{g}/\text{l}$	50	<1.0	<1.0	<1.0	<1.0
Zinc	mg/l	1.0	0.11	0.34	0.16	<0.001
Nitrates	mg/l	50	<0.50	<0.50	<0.50	1.9
Nitrites	mg/l	0.5	0.06	<0.05	<0.05	<0.05
Sulphates	mg/l	250	24.2	34.6	32.2	15.1
Fluorides	mg/l	1.5	<0.10	0.21	0.13	<0.10
Phosphates	mg/l	0.5	<0.10	<0.10	<0.10	<0.10
Chlorides	mg/l	250	12.9	10.3	30.2	15.6
Cyanides	$\mu\text{g}/\text{l}$	50	<5	<5	<5	<5
Natural uranium	mg/l	0.06	<0.020	<0.020	<0.020	<0.020

The studied parameter concentrations were compared to the values from the quality standard under Regulation 1 of October 10, 2007 on Exploration, Use and Protection of Groundwater. The results show low contents of the studied parameters and indicate a good chemical status of the ground water.

Many parameters such as antimony, mercury, cadmium, lead, selenium, phosphates, cyanides and natural uranium were shown to be below their lower detection limits. Volatile organic compounds (VOC), organochloric pesticides, organophosphorous and organonitric pesticides, general pesticides, benzapirenes, and polycyclic

aromatic hydrocarbons (PAH) are also below their lower detection limit values ($<0.010 \mu\text{g/l}$). The levels of the remaining studied elements are lower than the ground water quality standard levels.

Several exceptions of studied parameters deserve comment. Manganese levels are higher than the quality standard in most samples, and one sample showed higher iron levels. Both are rock-forming elements and frequently mobilize into the groundwater as the rocks weather. It is important to note in this regard that such increases in fissure water occurs also when these two elements deposit into the rock cracks as hydroxides. One sample (taken from RDD 021) shows a higher arsenic level ($\mu\text{g/l}$ 34). Usually, arsenic, selenium and antimony occur at higher levels together with heavy metals in rocks with hydrothermal mineralization. This can be seen both in the Sredna Gora ore zone and in the ore mineralizations in the Rhodopes. In this case, the content of arsenic only is higher, while selenium and antimony are not. Nickel is slightly higher in one of the samples. These singular increases do not merit deriving of clear trends. Such trends can be arrived at if a groundwater monitoring network is set up in the Rozino deposit and regular results over time are collected.

The main conclusion derived from the review of the chemical composition of ground water in the Palaeogene sediments and in the Metamorphous basement is that the values measured in the different boreholes are very similar and reflect a comparatively constant chemical composition of the ground water that is not altered by human activity. What is important in this case is that these results can serve as the baseline for background chemical composition of ground water during development of the deposit in the future.

10 Summarized hydrogeological characteristics

According to Bulgaria's adopted nomination, the groundwater bodies in the studied area are attached with a ground water body (GBW) with code BG3G000PtPg049 - Fissure Water – the Eastern Rhodopean Complex. The rocks of the groundwater body comprise lithology of diverse type and age. The geological formations are represented by a metamorphous basement and a Palaeogene sediment complex. The metamorphics are represented by a varied range of migmatites, serpentines, amphibolites, marbles, gneisses and granites. The Palaeogene sediment complex includes breccias and conglomerates, coarse grained to silty sandstones, marls and coal shales.

This GBW is among Bulgaria's most deficient in ground water, its rate of runoff being $<0.5 \text{ l/s/km}^2$. This explains the lack of water abstraction facilities built into the Palaeogenic sediments and in the metamorphics in the studied area.

The level of groundwater flowing through GBW IIBT BG3G000PtPg049 were measured on a regular basis in 8 boreholes in 2019-2022. The measurement results and the overall study results allow characterizing the GBW BG3G000PtPg049 in the studied Rozino IP area. Groundwater table during the period in question was measured as 4.82 to 31.33 m. below the surface and generally follows the landscape line. The water levels vary between 259.27 and 467.03 m. Borehole RDD-056 is an exception - the ground water there drain freely at elevation 368.75 m. The ground water is type-classified as fissure water.

The permeability of the water saturation rocks is very low, the filtration ratio varying between 2.11×10^{-7} and $2.13 \times 10^{-9} \text{ m/sec}$, and the conductivity ranging between 0.02 and 0.069 $\text{m}^2/24 \text{ h}$.

The water flowing into GBW BG3G000PtPg049 is fresh, with mineralization of $<1 \text{ g/l}$, and are neutral (pH 7.02 – 7.65). The chemical analyses show lower concentrations of the studied parameters as compared to the quality standard set forth in Regulation 1 of October 10, 2007. This shows a good chemical status of the ground water and the values measured in the different boreholes are very similar and reflect a comparatively constant chemical composition of the ground water that is not altered by human activity.

The water accumulated in the Palaeogene sediments in the studied area recharges mainly via fractures and tectonic discontinuities from adjacent horizons and via the metamorphous rocks of their basement. Combined with very low rock filtration ratios, the highly rugged terrain allows for very little recharging through surface water seepage.

The groundwater drains mainly to south-southeast. The hydrogeological characterization of GBW BG3G000PtPg049 in the studied Rozino IP area was based on a summary of hydrological-study results conducted in the area in accordance with Article 17 (1) item 1 of Regulation 1 of October 10, 2007 on Exploration, Use and Protection of Ground Water.

According to articles 13,14,15 and 16 of this Regulation, GBW BG3G000PtPg049 in the region is: heterogeneous of structure, heterogeneous of filtration properties, contained and uncontained by hydrogeological conditions, with complex boundary conditions, and is poorly studied, its state of research being classified as group III - poorly studied hydrogeological conditions.

Alluvial deposits have formed in the floodplain of the Byala Reka River. The alluvial deposits are represented by boulders, inequigranular rubble and sand in varying ratios, and include sandy-clayey lenses and interlayers. They are more than 5 - 6 m. deep in some parts. The deposits are sporadic, and having unsustained areas, they are not nominated as a delineated groundwater body and are not included in the List of Groundwater Bodies in the East Aegean Region. Also, 2 sections of the alluvial floodplains of the Byala Reka River and of its tributary Arpa dere were studied and their groundwater levels were measured in the 2021 - 2022 period.

Distinct highs of water level between October and November were measured. No clear low-level trend is shown but low levels were measured in February and March.

The water levels in the monitored boreholes varied between 0.04 and 4.24 m. below the surface during the period specified above. The groundwater is in direct hydraulic connection to the water of the Byala and the Arpa dere rivers.

The filtration ratio of the alluvial deposits is 1.5×10^{-4} – $5.8 \times 10^{-4} \text{ m/sec}$, and their transmissivity coefficient is 2.36 – 2.63 m^2/day .

The water circulating in the alluvial deposits is fresh, with total mineralization of <1 g/l, neutral (pH 7.11 – 7.28), and with a comparatively constant chemical composition unaffected by human activity, with good quality as compared to the standard set forth in Annex 1 to Regulation 1 of October 10, 2007.

The delluvial and colluvial soils are represented by sandy-clayey matrix with inclusions of angular rock pieces of varying sizes. The Quaternary cover is ubiquitous, although denuded in some small and steep sections. The district colluvisols and the colluvium vary in widely in depth, having been measured at up to 6 - 7 m. in some places. No ground water has been found in these materials.

11 Conclusion

The report summarizes the results from the hydrogeological studies in the Rozino deposit area.

The following hydrogeological conditions are presented:

- The filtration parameters of the lithological varieties (Palaeogene sediment complex and a Metamorphous foundation) comprising ground water body BG3G000PtPg049, the levels of the groundwater flowing through them have been measured and their chemical composition has been determined in accordance with Annex 1 to Regulation 1 of October 10, 2007. The structure, hydrogeological conditions of the upper aquifer layers and filtration properties of the groundwater body within the studied region were determined.
- The filtration parameters of the alluvial sediment (boulders, inequigranular rubble and sand, with sandy-clayey lenses and interlayers) formed in the Byala Reka river flood plain and in its tributary Arpa dere. The dependence of levels of groundwater flowing through the alluvium on the river water levels was established. The chemical composition of the groundwater was studied in accordance with Annex 1 of Regulation 1 of October 10, 2007.
- The filtration parameters of talus and colluvial soils (sandy clays with inclusions of angular rock pieces of varying sizes), comprising the cover of the groundwater body BG3G000PtPg049. It was established that no groundwater flows through it.

The facts, as presented and analysed, underlie the characterisation of the natural hydrogeological conditions in the Rozino Investment Proposal area.

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